The Use of Honey in Cake and Sweet Doughs[1]

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HONEY has been used as a sweetening agent for many years. The use of honey in the American home for baking of sweet goods probably came about because of its ready availability and superior sweetening properties. Commercial use of honey for sweet goods has not been extensive, although the literature contains a few references regarding its application and formulation (1, 2 & 3).

Honey is generally thought to have special properties which enhance the quality of sweet goods and improve the flavor of cake (4, 6). The greater sweetening power of honey is well known. Special flavor effects are dependent on floral source. Some investigators have pointed out that honey possesses greater hygroscopicity than sugars and syrups of other types (4, 5 & 6). It is likely that the hygroscopicity imparted to baked products would be a function of the concentration employed. Dunn and Bailey (7) observed that invert sugar imparted soft and spongy characteristics to biscuits, whereas sucrose produced hard, brittle products. This difference was associated with the hygroscopic nature of invert sugar.

The ability of honey to impart a rich bloom and brown color to baked products has been recognized (4, 5 & 6). The browning of baked goods has been ascribed to the formation of furfural (4), or to the reaction of reducing sugars with nitrogenous material contained in flour, milk and egg proteins. (5). It is possible that the reaction of reducing sugars with proteins is in large measure responsible for certain odors and flavors independent of floral aromas associated with a specific honey. Such browning reaction products in cake would be common to all honeys and invert syrups.

Honey used as an ingredient of cake presents certain problems not evident when it is used in yeast-leavened goods. The inversion of sucrose is readily accomplished by yeast, while sucrose remains essentially a non-reducing sugar in chemically leavened goods. Hence, it might be expected that honey would exhibit properties essentially associated with reducing sugar when used in chemically leavened baked goods. The higher concentrations would accentuate these properties. Some of these problems observed in white cake have been noted (6, 10, 11). It has been demonstrated that high concentration of honey causes cake crumb to darken with increasing intensity toward the bottom of the cake. Such darkening was not observed when sucrose was used.

Another problem associated with the use of honey in chemically leavened sweet goods is the acidic properties of honey. This problem has been studied by several investigators (6, 10, 11). Morgan (11) stated that the acidity of honey batters could be adjusted by the amount of sodium bicarbonate used in the formula. Lothrop and Bailey (5) did not obtain satisfactory results by adjusting the pH of batters with soda or any other neutralizing agent. They observed that cakes baked with soda were considerably darker than cakes baked without soda. Glabau (10) observed that cakes made from batters adjusted to a neutral pH gave the highest score.

In general, most of the evidence indicates that the concentration of free reducing sugar must not exceed 30 to 50 percent of the total sugar. It should be recognized, however, that the percentage of honey that can be substituted for sucrose in a formula is dependent on the total sugar requirement.

The object of this research has been to study the effects of various honeys on cake and sweet doughs, the determination of the maximum amount of honey that could be employed, and the establishment of specifications for honey to be used in cake and sweet dough products. White layer cakes, yellow base cakes, chocolate layer cakes and basic sweet dough were studied.

Experimental Results and Discussion

For purposes of conducting this research, honey from fifteen different commercially important floral sources was collected from widely separated sections of the United States. Chemical, grade, and color analysis are presented in Table I. These data indicate extreme color variation from white to dark amber. Natural moisture content ranges between approximately 15 to 20 percent. Total acidity expressed as ml. of 0.1N sodium hydroxide, ranged from 16 ml. to 56 ml. Active acidity expressed as pH ranged from 3.6 to 4.0. Total sugar content of the honeys calculated as invert sugar ranged from 74 to 82 percent. A wide range in the ratio of levulose to dextrose is indicated. It was observed that honeys of high levulose-dextrose ratio exhibited less tendency to crystalize, thus facilitating handling in the bakery.

Effect of Varying the Concentration of Honey

Preliminary studies using a pound cake formula were designed to show the effect of substituting honey for all of the sucrose. Cakes of poor quality were produced, due to dense structure, low volume, dark crumb color,

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TABLE I—CHEMICAL ANALYSIS, COLOR, AND GRADE OF HONEYS

Honey	Water	Color[1]	Grade	Ash	Nitrogen	Acidity[2]	pH	Total red. sugars[3]	Total sugars[3]	Sucrose	L/D[4]	Dextrin
	%			%	%	ml.		%	%	%		%
Horsemint	19.8	40	C	0.21	0.11	56.5	3.6	73.2	77.1	3.7	1.08	0.32
Spanish needle	18.1	73	A	.20	.09	17.1	4.4	72.8	76.6	3.6	1.38	1.93
Buckwheat	19.7	119	C	.09	.21	38.1	3.9	72.0	75.5	3.3	1.06	.54
Fall flowers	17.8	111	A	.17	.14	28.8	4.0	75.3	78.4	2.9	1.02	.50
Cotton	16.4	26	A	.18	.09	25.4	3.9	76.9	80.3	3.2	1.02	.39
Sweet clover	17.1	25	A	.07	.00	16.0	3.9	73.6	80.4	6.5	1.22	.15
Mesquite	17.2	32	A	.09	.00	15.8	4.0	75.5	77.6	2.0	1.20	.20
Ariz. alfalfa	15.1	44	A	.29	.01	20.4	4.0	76.9	80.3	3.2	1.03	.57
Star thistle	16.4	49	A	.13	.04	42.0	3.7	74.2	76.6	2.3	1.06	.64
Tupelo	18.8	54	C	.10	.03	18.4	3.9	72.0	74.2	2.1	1.39	.25
Eucalyptus	17.7	64	A	.24	.04	25.3	4.0	73.2	75.7	2.2	1.17	.43
White clover	15.9	22	A	.07	.00	16.5	3.8	76.7	80.8	3.9	1.06	.12
Orange	16.4	21	A	.07	.01	16.6	3.8	74.2	81.8	7.2	1.16	.19
Heartsease	17.0	50	A	.07	.05	20.6	4.0	76.8	80.3	3.3	1.09	.03
Light amber alfalfa	15.4	53	A	.16	.06	22.0	3.9	76.9	81.9	4.7	1.19	.12

[1] Color in millimeters Pfund.
[2] Acidity reported as ml N/10 NaOH per 100 g. honey.
[3] Total reducing sugars and total sugars calculated as invert sugar.
[4] Levulose-Destrose ratio.

and undesirable flavor. To overcome low volume and dense crumb character, various common leavening agents were introduced into the formula. The effect of these changes was to alleviate the low volume and dense character of the cakes. However, as a result of increased alkalinity due to the presence of these leavening agents, the darkening of crumb and the production of undesirable flavors were increased. The darkness of crumb ranged from a medium yellow at the top of the cakes to a medium brown at the bottom. Flavor and aroma resembled that of a scorched or burnt product, indicative of excessive "browning reaction." These results were independent of baking time or temperature and corroborate the findings of Lothrop and Bailey (5).

Attempts were made to neutralize the acidity of the honey prior to incorporating it in the formula. Sodium hydroxide, calcium oxide, ammonium hydroxide, di-ammonium hydrogen phosphate, and sodium bicarbonate were used. While it is possible to adjust the pH of honey with these reagents, it proved to be impractical. Eucalyptus honey was adjusted from a pH of 4.0 to 5.4 with ammonium hydroxide. During 14 days storage, the color of honey changed from 80 to 120 m.m. Pfund, and the pH changed from 5.4 to 5.1. This change in color, from light amber to dark brown, would be undesirable. The "browning reaction' is enhanced by shifting the pH to near neutral or alkaline.

It appeared as a result of this preliminary work that the use of high concentrations of honey created deleterious effects that could not be overcome readily. Thus, it was necessary to reduce the concentration of honey in formulas for further studies. Experiments performed on layer-type cakes using various concentrations of honey indicated that 40% of the sucrose could be replaced by honey in a formula where total sugar was 120% based on the weight of the flour. Buckwheat, fall flowers, horsemint, and heartsease honeys were shown to produce objectionable flavor and color effects. Therefore, in further experiments with white and yellow layer cakes these honeys were eliminated.

Use of Honey in Yellow Base Cake

Eleven acceptable honeys were used at a 40% sugar level and compared with control cakes made with 120% sucrose. All cakes were compared at

TABLE II—EFFECT OF HONEY SOURCE ON QUALITY OF YELLOW BASE CAKE

Type of Sweetening	Sealing weight	Volume in cc	CAKE SCORE									
			Volume	Crust color	Symmetry	Character of crust	Grain	Crumb color	Aroma	Taste	Texture	Total
			(15)	(5)	(10)	(5)	(15)	(10)	(10)	(20)	(10)	(100)
Sweet clover	600	1490	13	5	10	5	10	8	10	20	7	88
Mesquite	"	1500	14	5	10	5	10	7	10	20	7	88
Ariz. Alfalfa	"	1430	12	5	10	5	10	8	10	20	7	87
Star thistle	"	1420	12	5	10	5	10	8	10	20	7	87
Tupelo	"	1430	12	5	10	5	10	8	10	20	7	87
Eucalyptus	"	1460	13	5	10	5	10	7	10	20	7	87
White clover	"	1480	13	5	10	5	10	10	10	20	7	90
Orange	"	1505	14	5	10	5	10	10	10	20	7	91
Spanish needle	"	1500	14	5	10	5	10	5	10	20	7	86
Lt. Amb. Alfalfa	"	1500	14	5	10	5	10	7	10	20	7	88
Cotton	"	1440	12	5	10	5	10	9	10	20	7	88
Sucrose	"	1640	15	4	10	5	10	5	8	15	7	79

equivalent sugar and moisture levels. The formula was a moderately high-ratio type believed to be in wide commercial use. The formula was as follows:

Ingredient	*Per cent*
Flour	100
Sugar (Honey and/or Sucrose)	120
Emulsified shortening	40
Whole eggs	40
Liquid milk	106
Salt	3
Baking powder	5
Flavor (vanilla)	0.1

The cake batters were mixed in a Hobart N-50 mixer and were baked in 8-inch round layer tins at 350° F for 25 minutes. The scoring of the cakes was done the following day. The results are presented in Table II.

The volume of cakes made with honey was slightly lower than that for cakes made with sucrose. Later experiments showed that this could be overcome by increasing the amount of baking powder by 1%. All cakes made with honey possessed slightly richer crust color, but thickness and general character of the crust remained unchanged. Symmetry, grain and texture were equally good in all cakes.

Major differences between honeys and sucrose were observed in crumb color, taste and aroma. All honeys produced a yellowing effect on the crumb color. This effect was proportional to the color of the honey used. Particularly pleasing were the crumb colors of the cakes made with white clover, orange and cotton honey. Spanish needle honey caused an excessively yellow crumb.

A faint aroma and taste of honey was detected in cakes made with eucalyptus honey. Cakes made with orange and tupelo honeys retained strongly the pleasing aroma and taste of these honeys. All cakes made with honey appeared to have more appealing flavor than those made with sucrose, even though the honey flavor was not always detected. The cakes made with honey had superior eating qualities since they were less crumbly. Since this effect might be due to moisture difference in the cake crumb, the above cakes were subjected to storage tests.

Effect of Honey on Moisture Retention in Cakes

The storage tests were conducted by storing the unwrapped cakes at room temperature for 24, 48 and 72 hours. The percent of moisture loss for these cakes is presented in Table III. The cakes stored for 24 hours showed essentially no difference in the loss of moisture, but the results from 48 and 72 hour storage periods suggested that honey cakes retained moisture slightly better than cakes made with sucrose. The differences, however, were neither large nor conclusive. Therefore, further storage tests were designed in which 15 floral sources of honey were used, and the data submitted to statistical treatment.

TABLE III—LOSS OF MOISTURE DURING STORAGE FROM YELLOW BASIC CAKE MADE WITH HONEY AND SUCROSE

Type of Sweetening	24 hours % loss	48 hours % loss	72 hours % loss
Sweet clover	2.9	4.9	6.0
Mesquite	3.1	5.3	5.6
Arizona alfalfa	2.9	5.1	5.8
Star thistle	3.5	5.3	5.5
Tupelo	3.3	5.3	5.7
Eucalyptus	2.9	4.9	5.6
White clover	2.9	4.9	5.5
Orange	2.9	4.7	5.6
Spanish needle	2.9	4.9	5.5
Light amber alfalfa	2.7	4.9	5.8
Cotton	2.4	4.7	5.9
Sucrose	2.9	5.5	6.4

The effect of various honeys on moisture retention in cakes stored for seven days is shown in Table IV. The various honeys exhibited some variation in ability to retain moisture in the baked cakes. There is, however, no significant degree of correlation between the retention of moisture and the levulose-dextrose ratio. Other chemical data presented in Table I did not appear to correlate with moisture retention. Analysis of variance of these data showed that mesquite and the two alfalfa honeys did not vary significantly from sucrose. All others held significantly more moisture than sucrose.

Use of Honey in White Layer Cake

The use of honey in white layer cake would appear to present no problems different from those encountered in yellow layer cake, with the exception of crumb color effects. It is obvious that any dark color imparted by the honey to the white cake would be objectionable.

The experience with the yellow layer cake suggested that an increase in the baking powder might be beneficial. Accordingly, the rules of cake formula balance were applied and the following formula evolved:

Ingredient	*Percent*
Flour	100
Sugar (Honey and/or sucrose)	120
Emulsified shortening	45
Egg whites	52
Liquid milk	96
Salt	3
Baking powder	5.0-6.0
Cream of tartar	0.5
Flavor (vanilla)	0.1

The layer cakes were made by substituting honey sugar solids for

TABLE IV—EFFECT OF VARIOUS HONEYS ON RETENTION OF MOISTURE DURING SEVEN DAY STORAGE

Name	Rank	Crumb Moisture After Seven Days Storage	L/D Ratio
		%	
Buckwheat	1	19.72	1.06
Horsemint	2	19.54	1.08
Spanish needle	3	19.40	1.38
Fall flowers	4	19.19	1.02
Tupelo	5	19.17	1.39
Heartsease	6	18.92	1.09
Eucalyptus	7	18.78	1.17
Orange	8	18.71	1.16
Star thistle	9	18.68	1.06
Sweet clover	10	18.46	1.22
Cotton	11	18.34	1.02
White clover	12	18.28	1.06
Mesquite	13	18.04	1.20
Arizona alfalfa	14	17.94	1.03
Light amber alfalfa	15	17.78	1.19
Sucrose	16	17.74	....

TABLE V—EFFECT OF HONEY SOURCE ON WHITE CAKE SCORE

Type of Sweetening	Volume in cc	CAKE SCORE									
		Volume	Crust color	Symmetry	Character of crust	Grain	Crumb color	Aroma	Taste	Texture	Total
		(15)	(5)	(10)	(5)	(15)	(10)	(10)	(20)	(10)	(100)
Sweet clover	495	15	5	10	4	15	9	10	20	10	98
Mesquite	510	15	5	10	4	15	8	10	20	10	97
Arizona alfalfa	485	15	5	10	4	15	8	10	20	10	97
Star thistle	450	14	5	10	4	15	8	10	20	10	96
Tupelo	450	14	5	10	4	15	8	10	20	10	96**
Eucalyptus	460	14	5	10	4	15	7	10	20	10	95
White clover	500	15	5	10	4	15	9	10	20	10	98
Orange	465	14	5	10	4	15	9	10	20	10	97*
Spanish needle	450	14	5	10	4	15	5	9	20	10	92**
Light amber alfalfa	455	14	5	10	4	15	8	10	20	10	96
Cotton	450	14	5	10	4	15	9	10	20	10	97
Sucrose	445	14	5	10	4	15	10	10	19	10	97

* Pleasing aroma and taste of honey.
** Honey aroma of doubtful character.

40% sugar. The procedure of cake making was the same as that used for yellow layer cakes. The results of these studies are summarized in Table V.

Except for crumb color and volume the results were similar to those found for the yellow layer cakes. The volume of the cakes made with honey was comparable to that of the cakes made with sucrose. This demonstrated the advantage of increasing the amount of baking powder when honey is used in the formula. White clover, orange, cotton and sweet clover had very slight effects on crumb color, while all others darkened the crumb appreciably. It is evident, therefore, that few honeys would be acceptable for use in white cakes at concentrations of 40%. Spanish needle imparted a distinct yellow color to the crumb. It is believed from these data and those in Table I that the Pfund colorimeter value of honey for use in white layer cakes at 40% concentration should not exceed 26 m.m. The effect of any one honey on color of white cake would be proportional to the concentration employed in the formula. Aroma and flavor of orange and tupelo honeys were prominent in white cake.

Chocolate Cakes

It was believed that honey could be used in chocolate cakes in amounts greater than 40%. Preliminary experiments failed to bear this out. Aroma and flavor were affected seriously at honey levels higher than 40%. The cakes had a burnt flavor previously described as a "browning reaction". Experiments on chocolate cakes were carried through at the 40% honey level using the following formula:

Ingredient	*Percent*
Flour	100
Sugar (Honey and/or sucrose)	120
Emulsified shortening	45
Eggs	55
Milk	120
Cocoa	20
Soda	3.5
Salt	3
Vanilla	.1

Cakes were baked using each of the various honeys replacing a third of the sucrose. Control cakes contained 120% sucrose. The results are presented in Table VI.

Heartsease, horsemint, buckwheat and fall flowers honeys produced undesirable flavors and after taste. Aroma and flavor of spanish needle honey were faintly detected. The aroma and flavor of tupelo honey were very pro-

TABLE VI—EFFECT OF HONEY SOURCE ON QUALITY OF CHOCOLATE CAKE

Type of Sweetening	Scaling weight[1]	Volume in cc	Volume	Crust color	Symmetry	Character of crust	Grain	Crumb color	Aroma	Taste	Texture	Total
	oz.		(15)	(5)	(10)	(5)	(15)	(10)	(10)	(20)	(10)	(100)
Sweet clover	6	500	15	5	10	5	15	8	9	20	10	97
Mesquite	6	500	15	5	10	5	15	8	9	20	10	97
Arizona alfalfa	6	505	15	5	10	5	15	8	9	20	10	97
Star thistle	6	525	15	5	10	5	15	8	9	20	10	97
Tupelo	6	510	15	5	10	5	15	8	8	19	10	95*
Eucalyptus	6	505	15	5	10	5	15	8	9	20	10	97
White clover	6	525	15	5	10	5	15	8	9	20	10	97
Orange	6	500	15	5	10	5	15	8	9	20	10	97
Heartsease	6	525	15	5	10	5	15	8	5	10	10	83**
Horsemint	6	515	15	5	10	5	15	8	5	12	10	85**
Spanish needle	6	510	15	5	10	5	10	8	9	18	8	88
Buckwheat	6	500	15	5	10	5	10	8	0	5	8	66**
Fall flowers	6	500	15	5	10	5	10	8	3	10	8	74**
Lt. amber alfalfa	6	510	15	5	10	5	12	8	9	20	9	93
Cotton	6	525	15	5	10	5	12	8	9	20	9	93
Sucrose	6	525	15	5	10	5	15	10	10	20	10	100

[1] Baked weight—5.5 oz.
* Pronounced honey aroma and flavor.
** Undesirable flavor and aroma.

TABLE VII—EFFECT OF HONEYS ON QUALITY OF BASIC SWEET DOUGH

Types of Sweetening	Volume in cc	Volume	Crust color	Symmetry	Character of crust	Grain	Crumb color	Aroma	Taste	Texture	Total
		(15)	(5)	(10)	(5)	(15)	(10)	(10)	(20)	(10)	(100)
Sweet clover	2521	15	5	10	5	15	8.6	9	20	10	97.6
Mesquite	2491	15	5	10	5	15	8.6	9	20	10	97.6
Arizona alfalfa	2541	15	5	10	5	15	9.3	9	20	10	98.3
Star thistle	2504	15	5	10	5	15	9.3	9	20	10	98.3
Tupelo	2533	15	5	10	5	15	9.6	10	20	10	99.6
Eucalyptus	2479	15	5	10	5	15	9.3	9	20	10	98.3
White clover	2545	15	5	10	5	15	9	9	20	10	98
Orange	2529	15	5	10	5	15	9	10	20	10	99
Spanish needle	2537	15	5	10	5	15	10	9	20	10	99
Lt. amber alfalfa	2475	15	5	10	5	15	9	9	20	10	98
Cotton	2587	15	5	10	5	15	9	9	20	10	98
Sucrose	2550	15	5	10	5	15	8.6	9	20	10	97.6

nounced. It was not determined whether this honey-chocolate flavor would be acceptable consumerwise. The chocolate seemed to mask the flavors of other honeys completely.

Grain and texture were affected to varying degrees by spanish needle, buckwheat, fall flowers, light amber alfalfa and cotton honeys. Volume, crust color and character and symmetry of all the various cakes were good.

Crumb color of the honey cakes was unlike that of the control. The cakes containing 120% sucrose had a reddish crumb color, while all the honey cakes were of a brownish color. This is believed to be caused by the acid properties of honey, as they affect the final pH of the cake batter. Adjusting the pH with soda is a common means of arriving at a desired crumb color in chocolate cakes, and since desired color is a matter of the baker's choice, the effect of honey on this property is not considered significant. In further experiments an additional 10% of cocoa in the honey formula was found to produce a crumb color indentical with that of the control cakes.

Basic Sweet Dough

The use of honey in basic sweet doughs appears to present several advantages. The natural sweetening power of honey should add appeal to finished products. The use of honey should improve the rich color of crust and crumb. In order to demonstrate these effects, various honeys were introduced into the basic sweet dough formula.

Preliminary experiments established that 100% of the sucrose could be replaced by honey in the formula. Baked goods of excellent quality were produced with the following basic sweet dough formula:

Ingredient	*Percent*
Flour, bread	80
Flour, soft	20
Water	50
Yeast	5
Honey or sucrose	15
Nonfat dry milk solids	6
Salt	1.5
Shortening	15
Eggs	10

Buckwheat, fall flowers, heartsease, and horsemint honeys were eliminated from further study because of undesirable effects on flavor and aroma. The results of baking tests for the 11 desirable honeys are presented in Table VII.

Color of crust, shape of the units, crust character and texture were all very good. Grain of all the samples was excellent. Aroma and taste of all the samples also were very good. Orange and tupelo honeys caused a mild honey aroma and were regarded equally as more desirable than the other samples. All of the honeys produced aroma and flavor considered equal or superior to the sucrose samples. Whether the flavor effect of honey on sweet goods could be detected when the customary washes and toppings are added was not determined.

The greatest contrast between honey and sucrose products was recorded for crumb color. Each honey, except mesquite and sweet clover, produced a crumb with a richer, yellower appearance. The intensity of the yellowness of crumb color seemed to be proportional to the color of the honey itself, and in the instance of spanish needle honey, the crumb was exceedingly yellow, suggesting high egg content. Mesquite and sweet clover honeys produced a crumb color identical with that of the control. The handling and make-up properties of the various doughs were studied closely but no differences were observed.

Effect of Honey on Gas Production

Geddes and Winkler (8) have demonstrated that doughs made with honey at 4% concentration did not differ significantly from sucrose with respect to gas production in doughs. It was not shown what effect 15% concentration of honey might have. To demonstrate the effect of 15% honey on gas production an 8-gram sample of each dough was placed in the Blish-Sandstedt pressure meter and the gas production recorded for a 5-hour period. The mean gas productions for 11 honeys and sucrose are presented in Table VIII.

TABLE VIII—EFFECT OF HONEY ON GAS PRODUCTION

Honey	Gas Production cc for 4 hours
Spanish needle	138.2
Tupelo	135.9
Sweet clover	133.1
Mesquite	132.9
Eucalyptus	131.2
White clover	130.4
Light amber alfalfa	130.3
Orange	129.4
Sucrose	128.1
Cotton	126.9
Arizona alfalfa	126.5
Star thistle	125.6

Statistical analysis of the data showed that spanish needle and tupelo honeys produced significantly more gas than sucrose. At the 0.1% level of significance, all other honeys were equivalent to sucrose in gas production.

Effect of Honey Color on Crumb Color of Sweet Goods

It was of interest to determine whether the Pfund colorimeter value assigned to the honeys accurately re-

flected the effect of honey color on baked goods crumb color. To study the degree of correlation between color of baked goods and Pfund colorimeter value, sweet goods were baked using 15 floral sources of honey (Table I.) The baked goods were assigned numerical visual ratings of 1 to 15, the highest number representing the darkest color. The color of the crumb was also measured with the Photovolt reflectometer (12). The approximate ICI tri-stimulus values X, Y, and Z were used to correlate with the Pfund colorimeter value and the visual estimate. Results are presented in Table IX. It is evident from these data that the Pfund colorimeter value assigned to the honeys accurately reflects the color of crumb in baked goods.

TABLE IX—TABLE OF CORRELATION COEFFICIENTS

Correlation coefficients between visual estimate of color, Pfund colorimeter and tri-stimulus values		r
Visual Estimate vs. X	=	0.92
Visual Estimate vs. Y	=	0.91
Visual Estimate vs. Z	=	0.88
Pfund colorimeter vs. X	=	0.92
Pfund colorimeter vs. Y	=	0.96
Pfund colorimeter vs. Z	=	0.94
Visual Estimate vs. Pfund colorimeter	=	0.93
Correlation Coefficients at the 1% level of significance,* 14 D/F, r = 0.623.		

*Snedecor, G. W., "Statistical Methods", 4th Ed., Pg. 149, Table 7.3, The Collegiate Press, Inc., Ames, Iowa. (1946).

Summary of Results

It has been observed from the quality of products made during this research that most of the variables in honey such as levulose-dextrose ratio, ash, dextrin and protein content do not produce any noticeable effects on cake or sweet goods. Among those honeys employed in this research, several have been shown to be practical for use in both cake and sweet goods. These are cotton, sweet clover, mesquite, Arizona alfalfa, star thistle, tupelo, eucalyptus, white clover, orange and light amber alfalfa. These honeys improved moisture retention and increased the shelf life of cakes. These same properties improved eating qualities since they tended to eliminate dryness and crumbliness. Superior sweetening power of honey tended to impart richer flavor to all cakes, while orange and tupelo honeys are recommended when strong honey flavor is desired.

The concentration of honey for practical use was found to be limited to one-third of the total sugar in the formula. Higher concentrations resulted in the formation of undesirable crumb color and flavor. A one percent increase in leavening agent is desirable when 40% honey is used.

The use of honey in basic sweet dough has several advantages. These include richness of color in crust and crumb, improved eating qualities, and flavor.

The Pfund colorimeter value used for color grading of honeys was shown to be a reliable estimate of the effect of honey on crumb color of baked goods.

The following proposed specifications are intended to be used only as a guide for both producers and users of honey.

Tentative Proposed Specifications for Honey for Use in Cake Products

1. All honey containers should be clearly labeled, showing U. S. grade, floral source, moisture content, and color in m.m. Pfund as well as U. S. Department of Agriculture color standards.
2. Honey for use in cake should be U. S. Grade "A" or "B" according to "U. S. Standards for Grades of Extracted Honey", effective April 16, 1951.
3. Honey should be treated at 160° F for 30 minutes to retard granulation.
4. Predominant floral sources of buckwheat, fall flowers, heartsease, and horsemint honeys are not desirable for use in white, yellow or chocolate cakes.
5. Tupelo and orange blossom honeys are very useful for producing specific honey aroma and flavor in cakes. All other honeys are considered as satisfactory.
6. Only honey classified as white by the U. S. grade and color standards is recommended for use in white cake.

Tentative Proposed Specifications for Honey for Use in Yeast Leavened Sweet Goods

1. All honey containers should be clearly labeled, showing U. S. Grade, floral source, moisture content and color in m.m. Pfund as well as "U. S. Department of Agriculture Color Standards".
2. Honey for baker's use should be U. S. Grade "A" or "B" according to "U. S. Standards for Grades of Extracted Honey", effective April 16, 1951.
3. Predominant floral sources of buckwheat, fall flowers, heartsease or horsemint honeys are not recommended for use in sweet goods, except in blends containing not more than 10% buckwheat, or 15% fall flowers, heartsease, or horsemint. All other honeys are satisfactory in yeast sweet goods.
4. Honey should be treated at 160° F for 30 minutes to retard granulation and enzyme activity.

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